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the first annual report of the strong-motion instrumentation program

(1972–1973)

SPECIAL REPORT 108

CALIFORNIA DIVISION OF MINES & GEOLOGY

1974

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STATE OF CALIFORNIA • THE RESOURCES AGENCY • DEPARTMENT OF CONSERVATION

THE FIRST ANNUAL REPORT OF THE STRONG-MOTION INSTRUMENTATION PROGRAM
1972 - 1973

Prepared under the direction of
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State Geologist

March 1974

CALIFORNIA DIVISION OF MINES AND GEOLOGY
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CALIFORNIA DIVISION OF MINES AND GEOLOGY

Report of the State Strong-Motion Instrumentation Program
from its inception on 4 March 1972 until 30 June 1973

When scientists and engineers have information on the forces to be expected in an earthquake, they are better able to design buildings and other structures (such as dams, bridges, highways) that can withstand the strong ground shaking during earthquakes. However, the information presently available on the motions and forces developed is severely limited. Much more information is needed on the nature of strong ground motion in earthquakes, and the performance of structures subjected to that motion, before we can expect to locate, design, and build structures which will safely withstand earthquake effects.

A strong-motion seismograph (also called accelerograph) is an instrument designed to record the stronger vibrations caused by earthquakes. It does not record weaker vibrations, during which it remains in a passive state, but produces records only when a potentially or actually damaging earthquake takes place nearby and triggers the instrument. The type of seismograph used for recording most earthquakes is too sensitive for this use; it is driven "off-scale" by the very earthquake the strong-motion instrument records.

Until the San Fernando earthquake occurred, out of a total of 100 strong-motion records, we had only about 10 strong-motion recordings that were all useful in designing structures to be earthquake resistant. Strong-motion accelerographs were not developed until 1932 and even as recently as 1969 there were only some 300 instruments distributed throughout the state. Since then the Seismic Engineering Branch of the U.S. Geological Survey, cooperating with numerous other organizations, has increased the number of installations until there are now more than 500 instruments throughout the state. Nearly half of these instruments are in Los Angeles as a result of 1965 City ordinance requiring three accelerographs in each building over six stories in height. The other accelerographs are located elsewhere in the California coastal region. In the short period of time that these 500-plus instruments have been installed, there had been few strong motion records obtained until the San Fernando earthquake struck in 1971 to teach us many costly lessons.

It is necessary to have accelerographs in various types of structures to tell how those structures behaved during an earthquake. However, presently almost all accelerographs are in tall buildings. Although some idea of the ground motion can be determined from records within the buildings, that alone is not enough.

It is vitally important that there also be instruments located on soil and rock formations so the ground motion recorded may be studied and considered in construction design and land use decisions.

The disastrous San Fernando earthquake provided an abundance of valuable information from accelerographs. We have far more usable records now than in all previous years. But very few instruments were in the San Fernando area where most of the damage occured; 90 percent were in downtown Los Angeles where damage was minor, and we are still lacking data on the characteristics of the most damaging motions. Only two instruments were located on the ground in areas not influenced by building motion.

At this time, we are placing instruments

1) in geographic areas not yet covered;
2) on representative soil and rock sites throughout the state;
3) on a broad group of representative buildings and structures.

Until this is done, we will not have the information needed to make our homes and other structures safe from destructive earthquakes.

A number of California cities have adopted ordinances, generally based on the Uniform Building Code, requiring accelerographs in buildings of more than six stories.

Such regulations are excellent, and cities and counties that have adopted them are to be congratulated. But this is not enough. All regions of California, not just a few limited areas, are subject to earthquakes. The State Strong-Motion Instrumentation Program is intended to assure that the entire state is instrumented adequately.

No present ordinance requires strong-motion instruments in low buildings or on the ground, yet most earthquake injuries and fatalities have occurred in buildings less than six stories in height. Some smaller communities and lightly populated areas do not have strong-motion instruments, yet these may be the very areas which will provide critical knowledge to help protect, not only the area itself, but heavily populated areas miles away.

The majority of deaths in California earthquakes have occurred in low-rise buildings. Earthquakes causing fatalities have occurred in such rural areas as Inyo County and Del Norte County, as well as in populous Santa Clara, San Francisco, and Los Angeles Counties. Earthquakes have caused great damage up and down the Central Valley, in the Mojave Desert, and in the Cascade Range. Information must be collected from where the earthquakes are felt, and that means throughout California.

Because soil and rock types vary greatly across the state, sites must be chosen that reflect the variety of California's geology. Data gained in one area of the state will benefit people in all areas. It is not adequate to collect the data only in one or two parts of California.

It is necessary that there be a statewide program to assure that there will be coordination of effort, and a scientifically sound distribution of instruments.

The 1971 Legislature enacted and the Governor signed into law, Chapter 8 of Division 2 of the Public Resources Code (SB 1374), to establish and monitor a statewide Strong-Motion Instrumentation Program for recording earthquake motion in representative geological environments and representative structures throughout the State.

The Strong-Motion Instrumentation Program is funded by a .007 percent (7¢ per $1,000) assessment of the estimated building costs as determined by the issuance of building permits.

The California Division of Mines and Geology was directed to organize and monitor this program with the advice of an Advisory Board appointed by the State Geologist. The present Board consists of engineers and scientists with technical competence in engineering seismology, as well as representatives of local government, State and Federal agencies, and private organizations.

Membership of the Strong-Motion Advisory Board as of 30 June 1973 was comprised of:

H. Bolton Seed, Chairman - Earthquake Engineering Research Center, University of California, Berkeley

Frank E. McClure, Vice Chairman - McClure & Messinger, Consulting Structural Engineers

R. B. Matthiesen - Seismic Engineering Branch, U.S. Geological Survey

William K. Cloud - Seismographic Station, University of California, Berkeley

LeRoy Crandall - Structural Engineers Association of California, LeRoy Crandall & Associates

C. Martin Duke - Earthquake Engineering Research Institute, University of California, Los Angeles

Arthur L. Elliott - California Department of Transportation

Alfred Goldberg - International Conference of Building Officials,
California Chapter

Mary W. Henderson - League of California Cities

Donald E. Hudson - Earthquake Engineering Research Laboratory,
California Institute of Technology

Laurence B. James - California Department of Water Resources

William B. Joyner - U.S. Geological Survey

L. Dale Mills - County Supervisors Association of California

John F. Meehan - California Department of General Services
Office of Architecture and Construction

Gordon B. Oakeshott - Consulting Geologist

Karl V. Steinbrugge - State Mining and Geology Board

Ex-officio members:

Wesley G. Bruer - California Division of Mines and Geology

James E. Slosson - California Division of Mines and Geology

William M. Wells - California Division of Mines and Geology

The first organizational meeting of the Strong-Motion Advisory Board was held on 21 January 1972. At this meeting, a permanent chairman and vice-chairman were elected from members of the Board.

The Advisory Board met four more times during the fiscal years 1971-72 and 1972-73. At the first regular meeting and during subsequent meetings of the Advisory Board, plans regarding the implementation of the Strong-Motion Instrumentation Program were discussed and guidelines were given to the Division of Mines and Geology for carrying out this program.

Six committees were established within the Board concerning the following functions and purposes:

1. Executive Committee - To act on behalf of the Board on matters requiring attention between Board meetings.

2. Rules and Operating Procedures Committee - To develop a set of operating procedures to be followed by the Board in fulfilling its intended role in the Strong-Motion Instrumentation Program.

3. Site Selection Committee - To recommend, together with general indication of priority, sites and structures where strong-motion instruments should be located in order to fulfill the objectives of this program.

4. Instrumentation Committee - To make recommendations concerning the selection, purchase, maintenance, and installation of all instruments used in the program.

5. Allocation of Funds and Resources Committee - To make recommendations concerning the desirable allocation of funds between various aspects of the Strong-Motion Program including purchase of instruments, maintenance, evaluation of site conditions, staffing, etc.

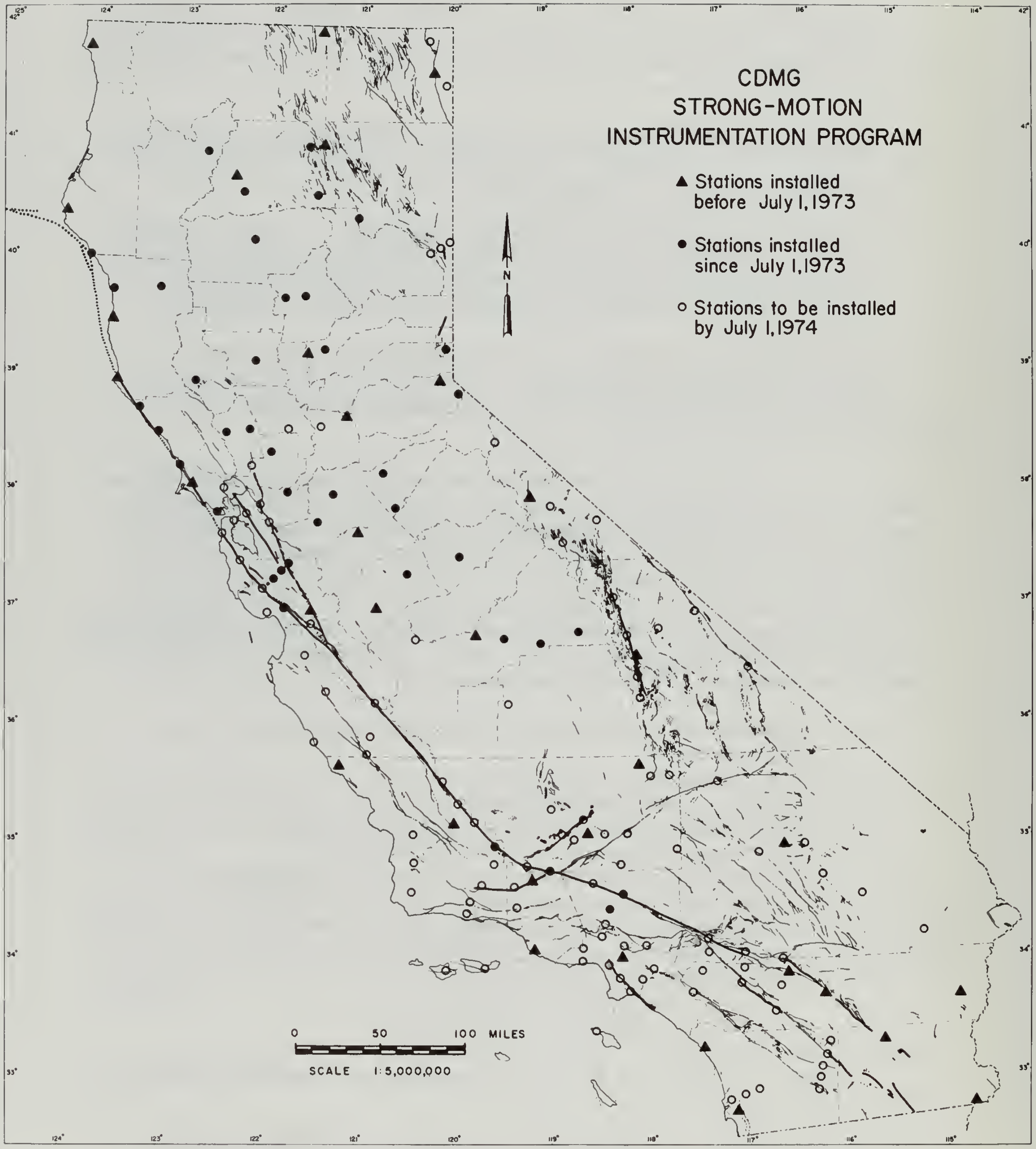
6. Public Information Committee - To advise the Board on public information matters and report information concerning the program to the public.

At the beginning of the Strong-Motion Instrumentation Program, many questions regarding the law were raised by local governments. It was soon realized that not enough information concerning the program had been sent to local governments to acquaint them with the program and the benefits to be derived. One of the first directives made by the Advisory Board was for the preparation of a brochure describing the program and value to be derived that would be applicable to all parts of the State. A brochure was prepared and distributed to the following groups.

1. City and county building permit departments
2. City councils
3. County boards of supervisors
4. League of California Cities
5. County Supervisors Association of California
6. Earthquake Engineering Research Institute
7. Structural Engineers Association of California
8. California Builder's Council
9. International Conference of Building Officials
10. State Senators and Assemblymen
11. Joint Committee on Seismic Safety
12. Governor's Earthquake Council
13. Association of General Contractors.

Other decisions and directives made by the Advisory Board and its committees were the following:

1. The Site Selection Committee, considering the whole State, selected 40 sites to be instrumented during the 1972-73 fiscal year. The criteria used in selecting these sites for instrumentation were: (a) in geographic areas not yet instrumented; (b) representative soil and rock sites; and (c) fault zones.



Locations of strong-motion accelerograph stations installed and soon to be installed under the State Strong-Motion Instrumentation Program. (See November 1973 EQSNL for short article on this subject.)

The first consideration for selection of sites should be technical and not political. Sites should be scientifically selected. Whether or not a county or city is exempt from the program should not be a prime factor in site selection, inasmuch as information obtained from strong-motion recordings in one part of the State is applicable or otherwise valuable to most other parts of the State.

2. For the fiscal year 1973-74, the Advisory Board initially directed the Division to install at least 100 strong-motion instruments. During later meetings, the Site Selection Committee chose a large number of arrays and single instrument sites that would require the installation of some 150 instruments. The Division plans to install these 150 instruments in fiscal year 1973-74, and in addition, plans to install 50 more instruments in other sites and selected structures.

3. The Strong-Motion Instrumentation Program is to be carried out in cooperation with other government agencies, both State and Federal. All State instruments are integrated into the Strong-Motion Network of the Seismic Engineering Branch of the U.S. Geological Survey. The U.S. Geological Survey collects all strong-motion instrument records from any earthquake in California, for processing, and makes the data available on request to all interested scientific and engineering organizations.

During the fiscal year 1972-73, 40 instruments were installed throughout the State in the following locations (See Map):

No.	Station	County
1	Point Arena (rock-fault zone)	Mendocino
2	San Simeon (alluvium)	San Luis Obispo
3	Point Reyes (alluvium-fault zone)	Marin
4	Walker Pass (rock)	Kern
5	Cape Mendocino (rock)	
6	Gilroy (alluvium)	Santa Clara
7	Corralitos (rock-fault zone)	Santa Cruz
8	Sutter Buttes (rock)	Sutter
9	Folsom (rock)	Sacramento
10	Fresno (alluvium)	Fresno
11	Modesto (alluvium)	Stanislaus
12	Los Banos (alluvium)	Merced
13	Manix (alluvium-fault zone)	San Bernardino
14	California Valley (rock)	San Luis Obispo
15	Lone Pine (alluvium-fault zone)	Inyo
T-1	NAS Point Mugu (alluvium)	Ventura
T-2	NAS Point Mugu (alluvium)	Ventura
T-3	NAS Laguna Peak (rock)	Ventura
T-4	UCB Oxnard (alluvium-building)	Ventura
T-5	Resources Building (alluvium-building)	Sacramento

No.	Station	County
T-6	Resources Building (alluvium-building)	Sacramento
16	Fort Bragg (alluvium)	Mendocino
17	Crescent City (alluvium)	Del Norte
18	Tule Lake (alluvium)	Siskiyou
19	MacArthur (alluvium)	Shasta
20	Oceanside (alluvium)	San Diego
21	Blythe (alluvium)	Riverside
22	Winterhaven (alluvium)	Imperial
23	Niland (alluvium-fault zone)	Imperial
24	Shasta (rock)	Shasta
25	Palm Springs (alluvium)	Riverside
26	Indio (alluvium-fault zone)	Riverside
27	San Diego (rock)	San Diego
28	L.A. Bunder Hill (shale)	Los Angeles
29	Lockwood Valley (alluvium-fault zone)	Ventura
30	Cummings Valley (rock)	Kern
31	Mono Lake #1 (rock)	Mono
32	Emerald Bay (rock)	El Dorado
33	St. Helena (rock)	Napa
34	Berryessa (rock)	Napa

The 40 listed instrument sites were distributed throughout the State to provide a beginning for a statewide, strong-motion network. Instruments were placed in 25 counties in California. Four of the instruments were temporarily installed in the Oxnard area the day after the 5.75 magnitude earthquake at Point Mugu on 21 February 1973. Two instruments, installed on a temporary basis in the Resources Building in Sacramento, are to be removed and re-installed, if needed, to record aftershocks on any earthquakes in California.

The first strong-motion record obtained from a State instrument was the recording of an aftershock on 22 February 1973, the day after the Point Mugu earthquake.

The following instrument sites, as chosen by the Site Selection Committee, have been designated to the following areas, either as single instrument locations or arrays (See Map), for installation during the 1973-74 fiscal year. Instruments are to be placed on different geological formations, and either along or across major faults throughout the State. Additional instruments not listed below will also be installed in metropolitan areas and on some special structures to bring the total number of instruments to be installed during the 1973-74 fiscal year to 200.

SOUTHERN CALIFORNIA

No.	Area	Number of Instruments	County
1	San Diego Array	3	San Diego
2	Santa Barbara-Goleta Array (NW towards Maricopa across Santa Ynez and Big Pine faults)	5	Santa Barbara and Kern
3	Ventrua Array (north across Santa Ynez fault)	3	Ventura
4-5	Newport-Inglewood Array (across Newport-Inglewood fault)	3	Los Angeles
6	San Fernando Array (across valley to mountains)	3	Los Angeles
7	San Bernardino Array (across Whittier-Elsinore fault to San Andreas fault)	4	San Bernardino and Riverside
8	Riverside Array (across San Jacinto and San Andreas faults)	3	San Bernardino and Riverside
9	San Jacinto Array (across San Jacinto and San Andreas faults)	3	San Bernardino and Riverside
10	Aqua Caliente-Elsinore Array (across Aqua Caliente, Elsinore and San Jacinto faults)	5	Riverside and San Diego
13	Santa Maria-Lompoc Array	3	Santa Barbara
14	Walker Pass Array (extend to Ridgecrest)	3	Kern
15	Manix Array (extend to Barstow)	2	San Bernardino
18	Boron	1	Kern
19-24	Bakersfield-Tehachapi-Mojave Array	5	Kern
24a	Mojave to San Fernando Array	3	Kern and Los Angeles

SOUTHERN CALIFORNIA (continued)

No.	Area	Number of Instruments	County
25-26	White Wolf fault (instruments on each side of fault)	2	Kern
33	Searles Lake-Trona	1	San Bernardino
34	Ludlow	1	San Bernardino
35	Amboy	1	San Bernardino
36	Danby Lake	1	San Bernardino
45	Santa Catalina Island	1	Los Angeles
46	Santa Cruz Island	1	Santa Barbara
47	Santa Rosa Island	1	Santa Barbara
	Los Angeles (free field stations)	4	Los Angeles
	TOTAL FOR SOUTHERN CALIFORNIA:	62	

NORTHERN CALIFORNIA

No.	Area	Number of Instruments	County
48	Alabama Hills	1	Inyo
49	Owens Valley Array (along Sierra Nevada fault)	4	Inyo and Mono
50	Crowley Lake	1	Mono
51	Mono Lake (soil site) #2	1	Mono
52	Coleville	1	Mono
53	South Tahoe	1	El Dorado
54	Ft. Sage-Honey Lake Array (across Ft. Sage-Honey Lake faults)	3	Plumas and Lassen
55	Surprise Valley	1	Modoc

NORTHERN CALIFORNIA (continued)

No.	Area	Number of Instruments	County
56	Bodega Head-Santa Rosa-Sacramento Array	6	Sonoma, Napa, Yolo, and Sacramento
57	Point Arena-San Juan Bautista Array (along San Andreas fault)	7	Mendocino, Sonoma, Marin, San Francisco, San Mateo, Santa Clara and San Benito
58	San Jose-Santa Clara Array	2	Santa Clara
59	Cholame-San Bernardino Array	7	San Luis Obispo
*60	Stockton	1	San Joaquin
61	Merced	1	Merced
62	Santa Cruz (soil site) #1	1	Santa Cruz
63	San Francisco-Concord Array (from Seal Rock through San Francisco to the east of Hayward fault)	4	San Francisco, Alameda, and Contra Costa
64	San Rafael	1	Marin
65	Tulare	1	Tulare
66	Vacaville (soil site) #1	1	Solano
67	Marysville	1	Yuba
68	Napa	1	Napa
69	Salinas	1	Monterey
70	Redding	1	Shasta
71	Red Bluff	1	Tehama
72	Chico (soil site) #1	1	Butte
73	Hernandez or Priest Valley	1	Monterey

NORTHERN CALIFORNIA (continued)

No.	Area	Number of Instruments	County
97	Lassen Park	1	Shasta
98	Truckee	1	Nevada
99	Long Valley	1	Monterey
100	Death Valley	1	Inyo
101	Shelter Cove (soil site) #1	1	Humboldt
102	Shelter Cove (rock site) #2	1	Humboldt
103	Rockport	1	Mendocino
	TOTAL FOR NOTHERN CALIFORNIA	86	
	TOTAL FOR SOUTHERN CALIFORNIA	62	
	TOTAL INSTRUMENTS =	148	46 Counties

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*Sites numbered 60 through 94 were originally proposed by the Earthquake Engineering Research Institute and National Oceanic and Atmospheric Administration (December 1971), H. Bolton Seed, Chairman of EERI Committee.

NORTHERN CALIFORNIA (continued)

No.	Area	Number of Instruments	County
74	Kelseyville	1	Lake
75	Danville (soil site) #1	1	Contra Costa
76	Anticoch	1	Contra Costa
78	Covelo	1	Mendocino
79	Mendota	1	Fresno
80	Jenny Lind	1	Calaveras
81	Williams	1	Colusa
82	Westwood (Lake Almandor)	1	Lassen
83	Greenfield	1	Monterey
84	Chico (rock site) #2	1	Butte
85	Vacaville (rock site) #2	1	Solano
86	Danville (rock site) #2	1	Contra Costa
87	Tracy	1	San Joaquin
88	Melones Reservoir	1	Calaveras
89	U.C. Santa Cruz (rock site) #2	1	Santa Cruz
90	Nacimiento	1	San Luis Obispo
91	Mariposa	1	Mariposa
92	Davis Creek (east of Goose Lake)	1	Modoc
93	Burney Falls	1	Shasta
*94	Cape San Martin	1	Monterey
95	Fresno to North Death Valley array	6	Fresno, Tulare, and Inyo
96	Trinity Alps	1	Trinity

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